Arctic Research Initiative 1996; Arctic Research Office 1999-2005; Arctic Research Program, CPO 2005-2013

Status and New Challenges

July 17, 2013
5th Symposium on the Impacts of an Ice-Diminishing Arctic on Naval and

Maritime Operations

Kathleen Crane

Climate Observation Division

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Arctic Research Program
Climate Observations Division

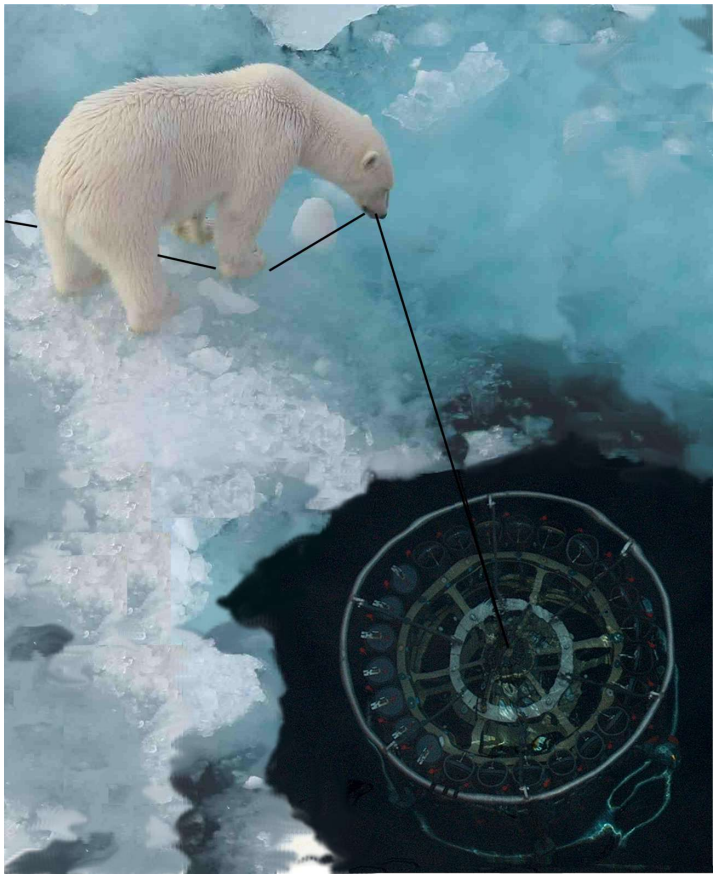
Kathleen Crane

GOALS: 2002-2012

- To capture the transition of the Arctic from an ice covered ocean to an ocean where ice may disappear in the summer by 2030.
- Facilitate and deploy Arctic regional observational equipment (focused on the Pacific Arctic),
  - Arctic Atmospheric Observatories
  - Ice-Ocean-Ecosystem changes
  - Sea Ice Thinning: Causes and Consequences
- Carry out analysis of key variables in the atmosphere, ice, ocean and marine ecosystem parts of the Arctic climate system
- Document variability, detect change and evaluate impacts on marine ecosystems.

GOALS: 2013-2014

- Focus on data and information analysis and synthesis RUSALCA
- Elucidate a new decade of Arctic Observations beginning in 2014



Strategic Partners:

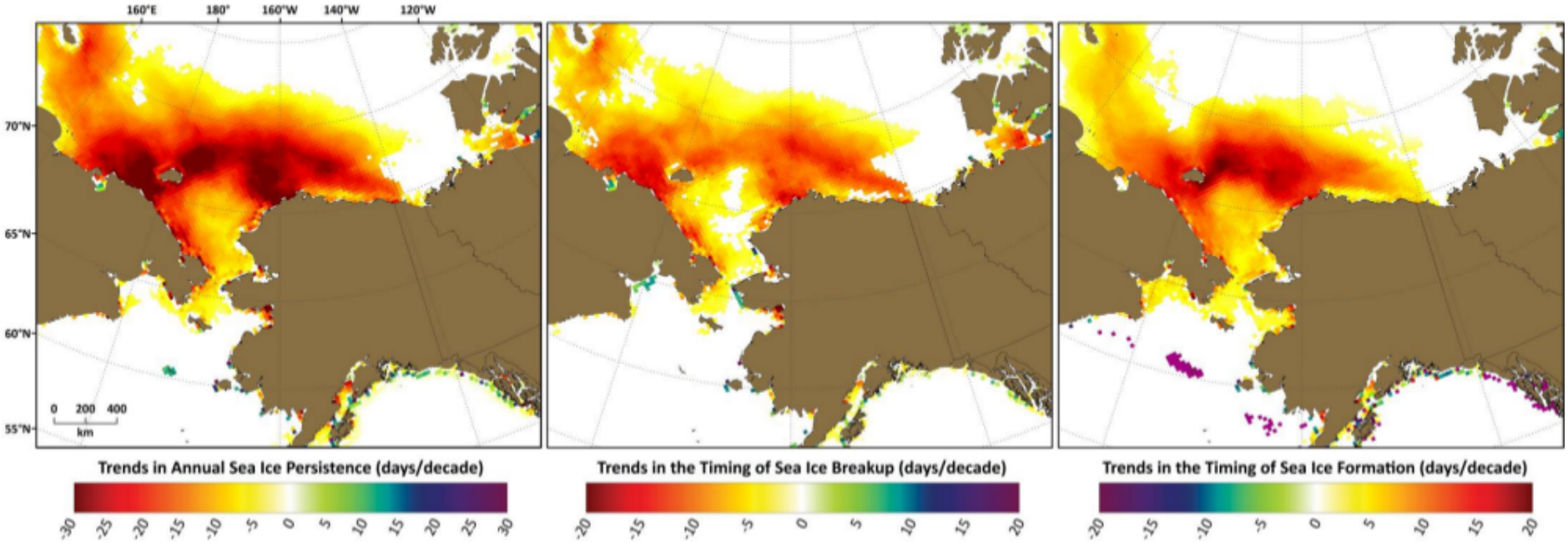
OAR OER, ESRL, PMEL, GLERL, AOML, GFDL

NOAA Lines NMFS-AFSC, NESDIS-NIC, NOS-AOOS

Interagency NSF, ONR, FWS, BOEM, NASA, USGS

US Academia UAF, WHOI, UW, UMD , OSU,CIs

Trends In Sea Ice Reduction in The Pacific Arctic: A Thermal Bulls-Eye where Pacific and Atlantic Waters Meet : Driver for RUSALCA in 2003



Fewer Days of Sea Ice Cover

Earlier Break up of Sea Ice

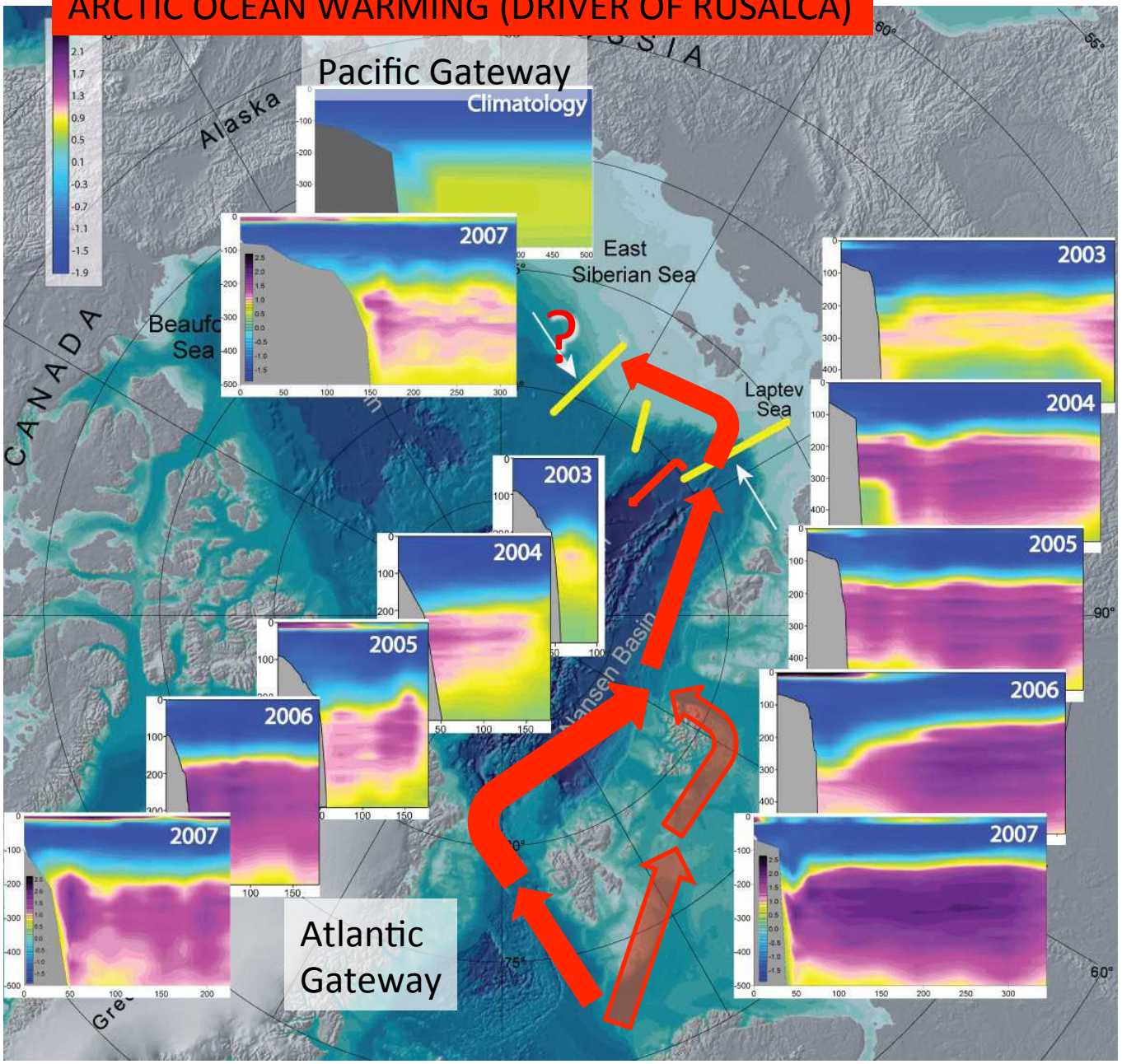
Later Fall Sea Ice Formation

From K. Frey

SEA ICE OBSERVATIONS IN 2003- DRIVER FOR THE RUSALCA PROGRAM

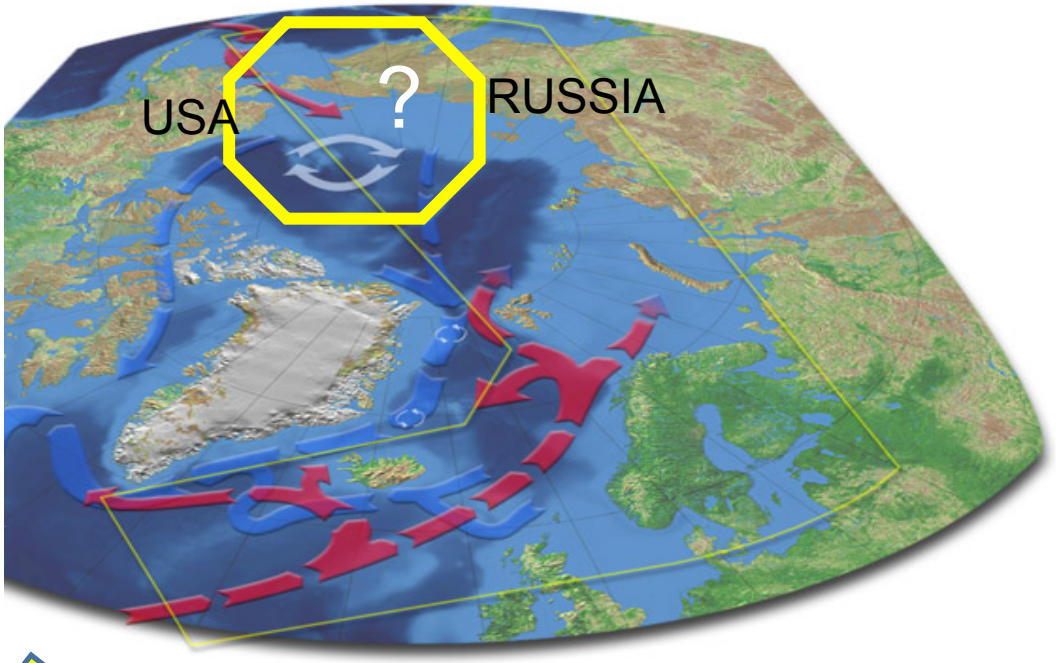
Influx of a Warm Pulse of Atlantic Water Towards the Pacific Arctic- NABOS 2003-2007

ARCTIC OCEAN WARMING (DRIVER OF RUSALCA)

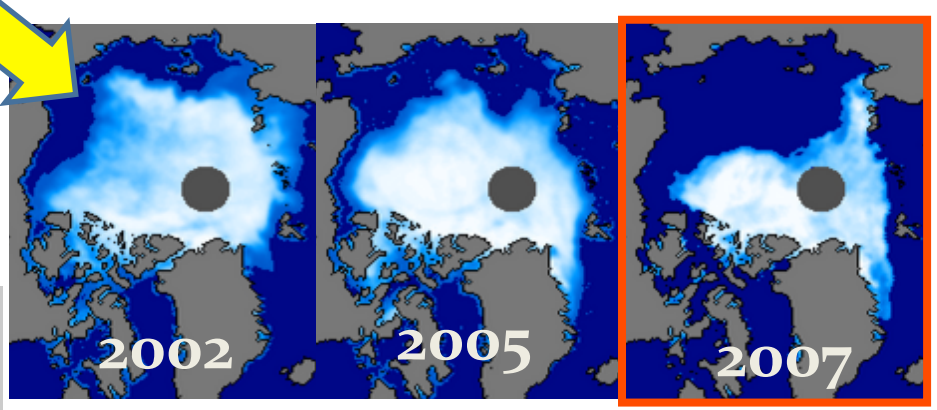


Russian American Long-term Census of the Arctic (RUSALCA)2003-2013

1. **Take observations Where Arctic sea ice reduction is a maximum in the Pacific Arctic**
2. **Monitor fresh water, heat, nutrient fluxes and transport pathways through the Pacific Gateway to the Arctic**
3. **Monitor ecosystem indicators of climate change in the Pacific Arctic**
4. **Monitor changes in ecosystems and Arctic wide physical systems that impact global climate and ecosystem stability**
5. **Improve Russian-U.S. Arctic science relations**
6. **Explore the unknown Arctic**



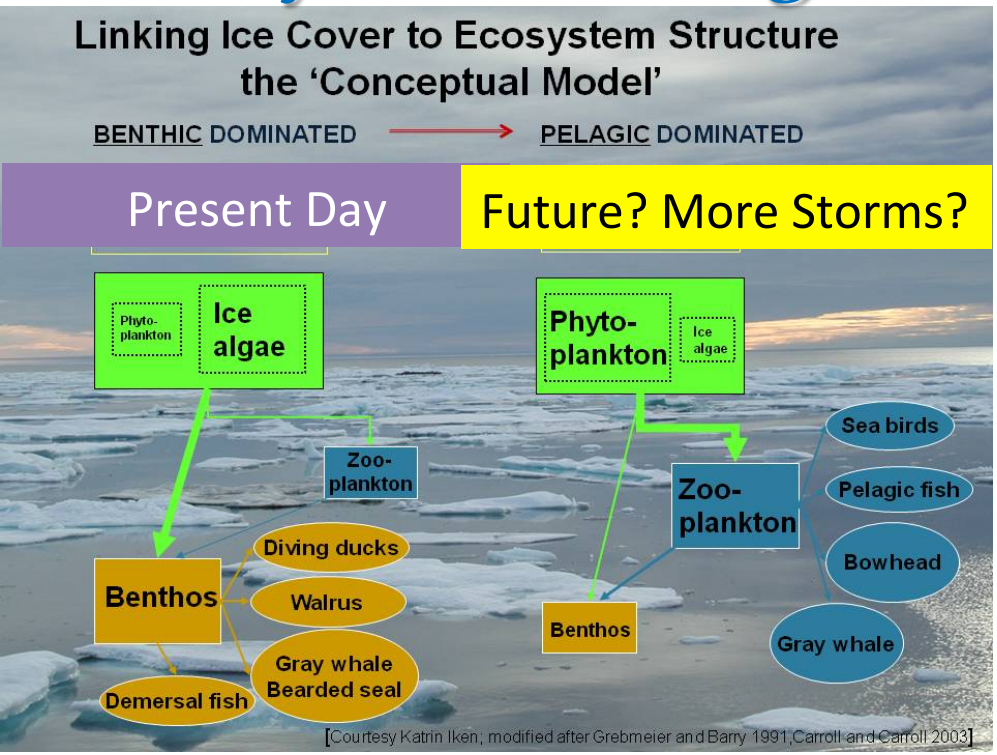
FUNDED BY NOAA, NSF, RAS



Bering Strait heat flux is triggering sea ice loss

Oceanic fluxes of volume and heat through the Bering Strait increased by ~50% between 2001 and 2011

Learned so far? Loss of sea ice and ecosystem change.

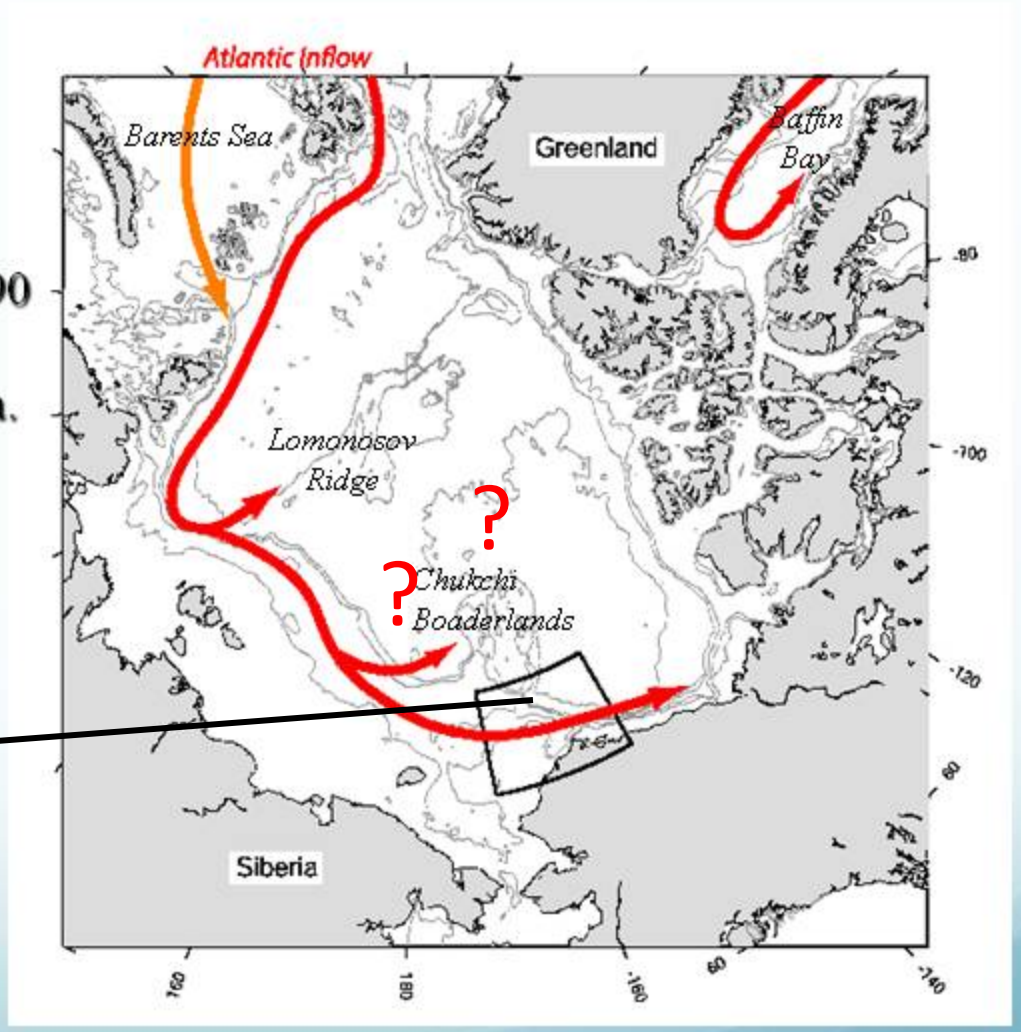


- Ocean Acidification,
- Benthic and Epibenthic Census and Processes,
- Census of Zooplankton
- Biodiversity of Fish and Assessment
- Nutrients and Productivity
- Physical and Chemical Oceanography (Bering Strait Fluxes)
- Paleo-oceanography, geology and seafloor-ocean fluxes
- Seafloor permafrost stability
- Methane
- Census of Marine Mammals

Role of Atlantic Water Transport and Warming on the Migration of Atlantic Arctic Fish into the Pacific Arctic

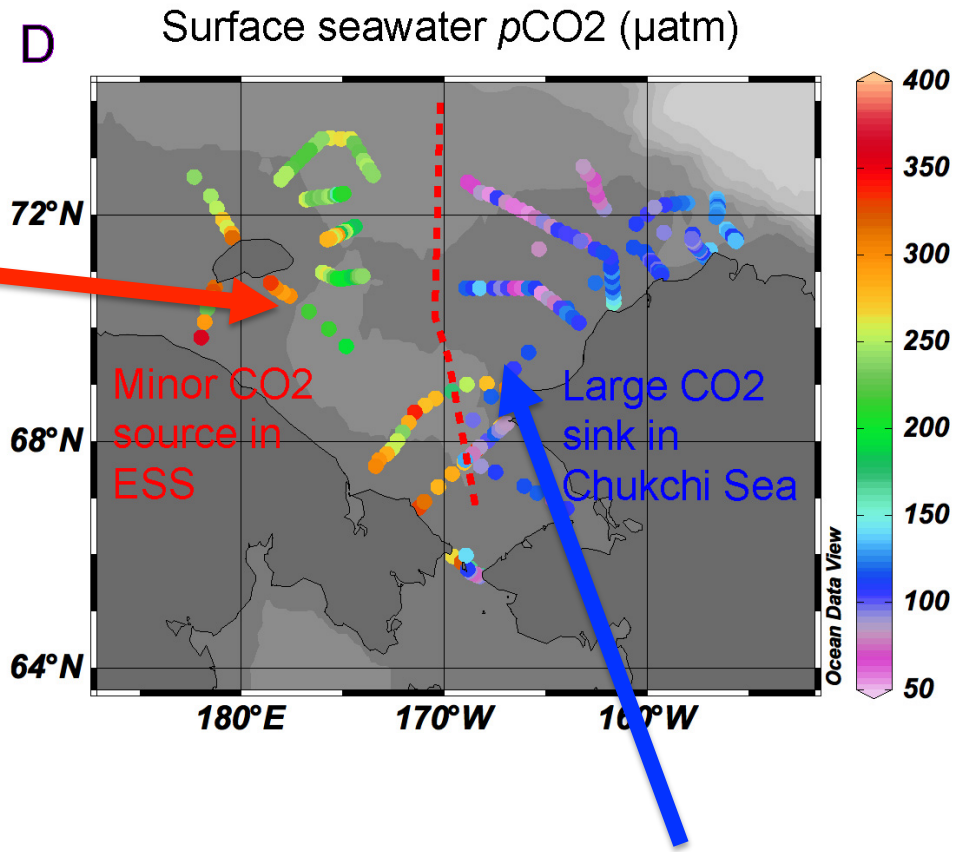
- Warming of AW inflow since 1980.
- Two pronounced pulses: one around 1990 and the other around 2000, tracked by hydrographic sections and mooring data.

Atlantic Hookear Sculpin



Mecklenburg, 2010
Pickart, 2010

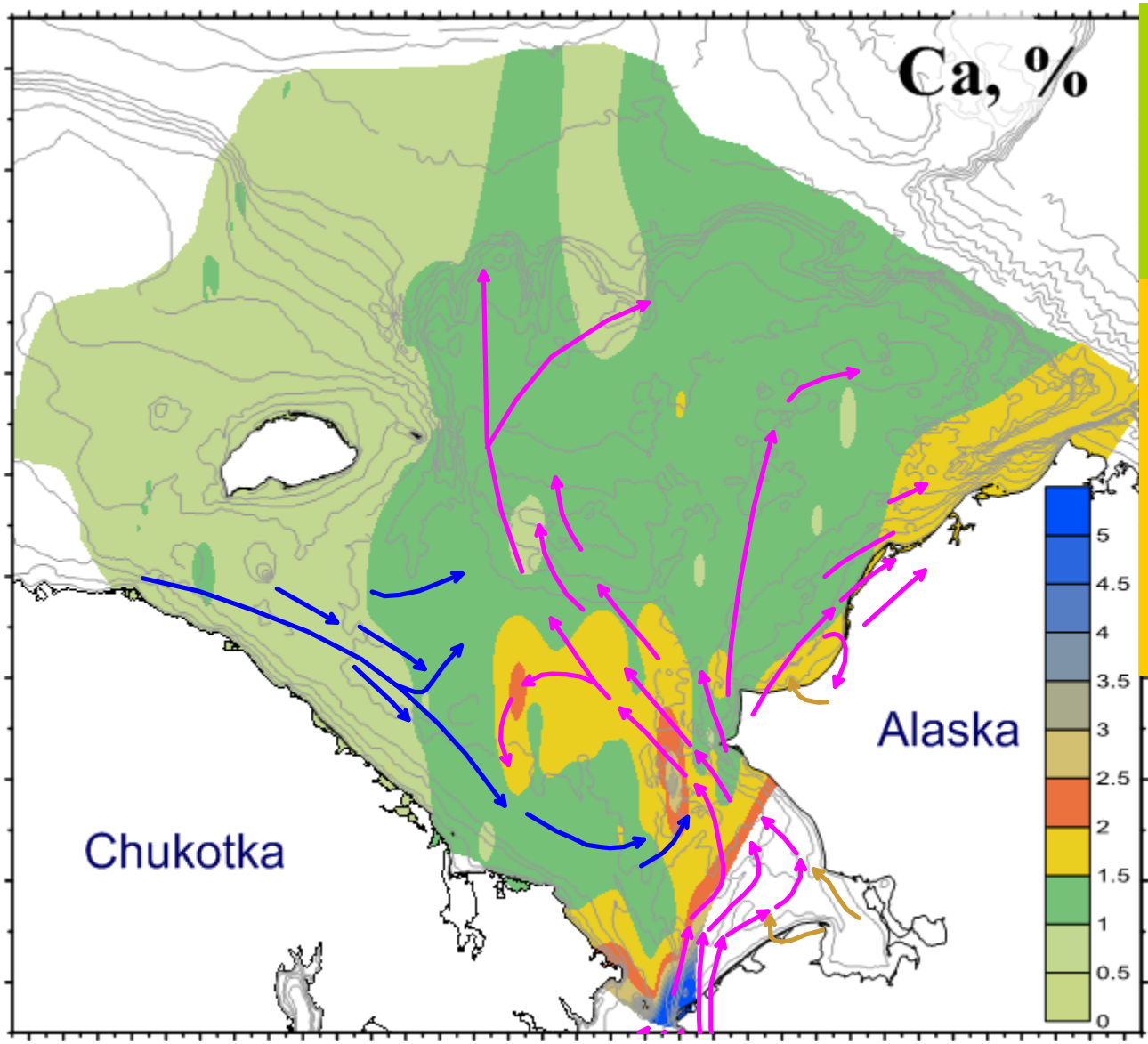
Loss of Sea Ice Impacts on Arctic Ocean Acidification RUSALCA



Ocean Release of CO_2

N. Bates, 2011

large ocean uptake of CO_2 in area of low seawater pCO_2



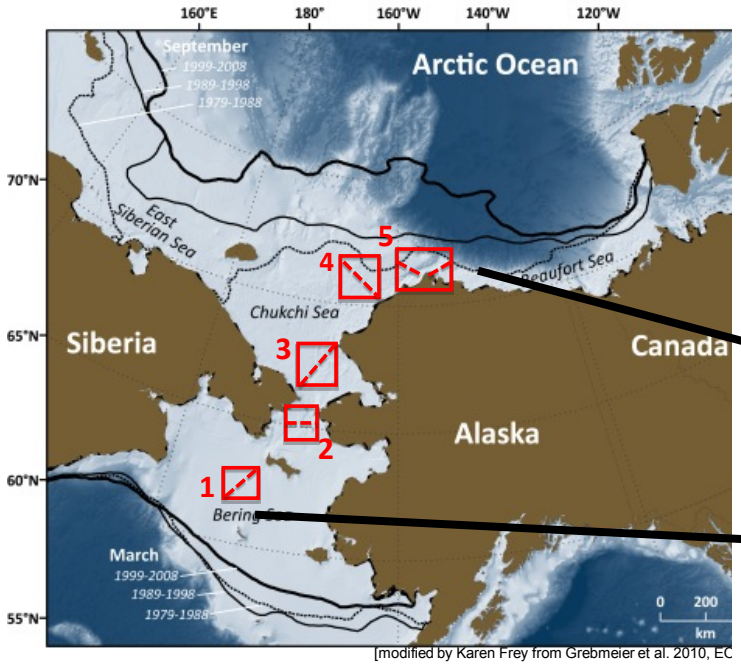
Geologically lower concentrations of Calcium in the surface sediments of the Western Chukchi Sea

Geologically higher Concentrations of Calcium in the Surface Sediments of the Eastern Chukchi Sea

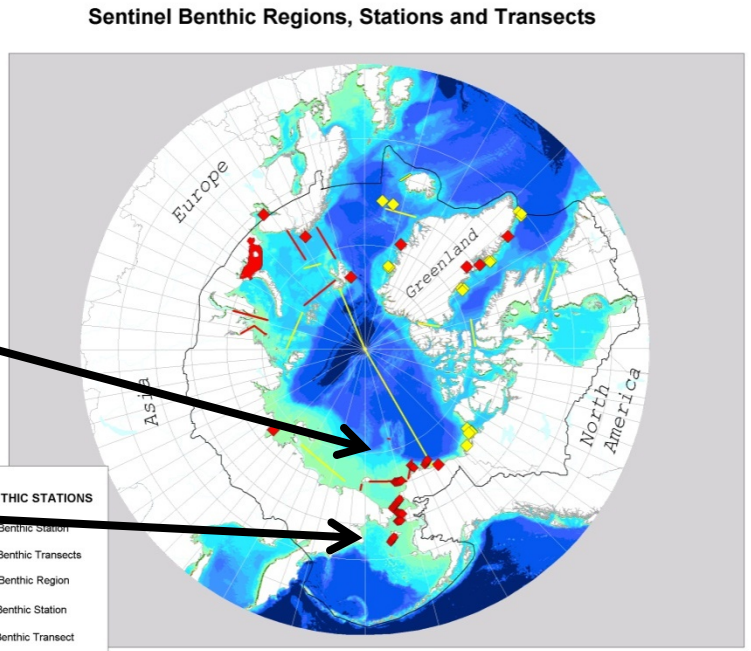
RUSALCA

Astakhov et al, 2013

Unique Value and Successes: Arctic Council Sentinel Marine Stations CBMP-Marine (RUSALCA-DBO)



[modified by Karen Frey from Grebmeier et al. 2010, EC



Sentinel Benthic Stations (Arctic Council)

<u>The Distributed Biological Observatory</u>: Linking Physics and Biology under conditions <u>of sea ice loss</u>.

Increase ability to monitor and assess environmental conditions under changing climate scenarios through new collaborations and partnerships

- With Arctic residents
- Across U.S. agencies.
- Internationally, e.g., Pacific Arctic Group, Arctic Council

RUSALCA

ARCTIC COUNCIL

The DBO sites currently occupied by national and international entities with a shared data plan include Canada, China, Korea, Japan, Russia, and the United States. Sampling includes:

CTD, ADCP measurements
Chlorophyll
Nutrients
Ice algae/Phytoplankton (size, biomass and composition)
Zooplankton (size, biomass and composition)
Benthos (size, biomass and composition)
Seabird (standard transects, no additional ship time)
Marine mammal observations (no additional ship time)
Fishery acoustics
Bottom trawling (every 3-5 years)

Lower prey and higher trophic predators have undergone range changes (zooplankton, benthos, and fish), and loss of sea ice has destroyed habitat platforms for marine mammals.

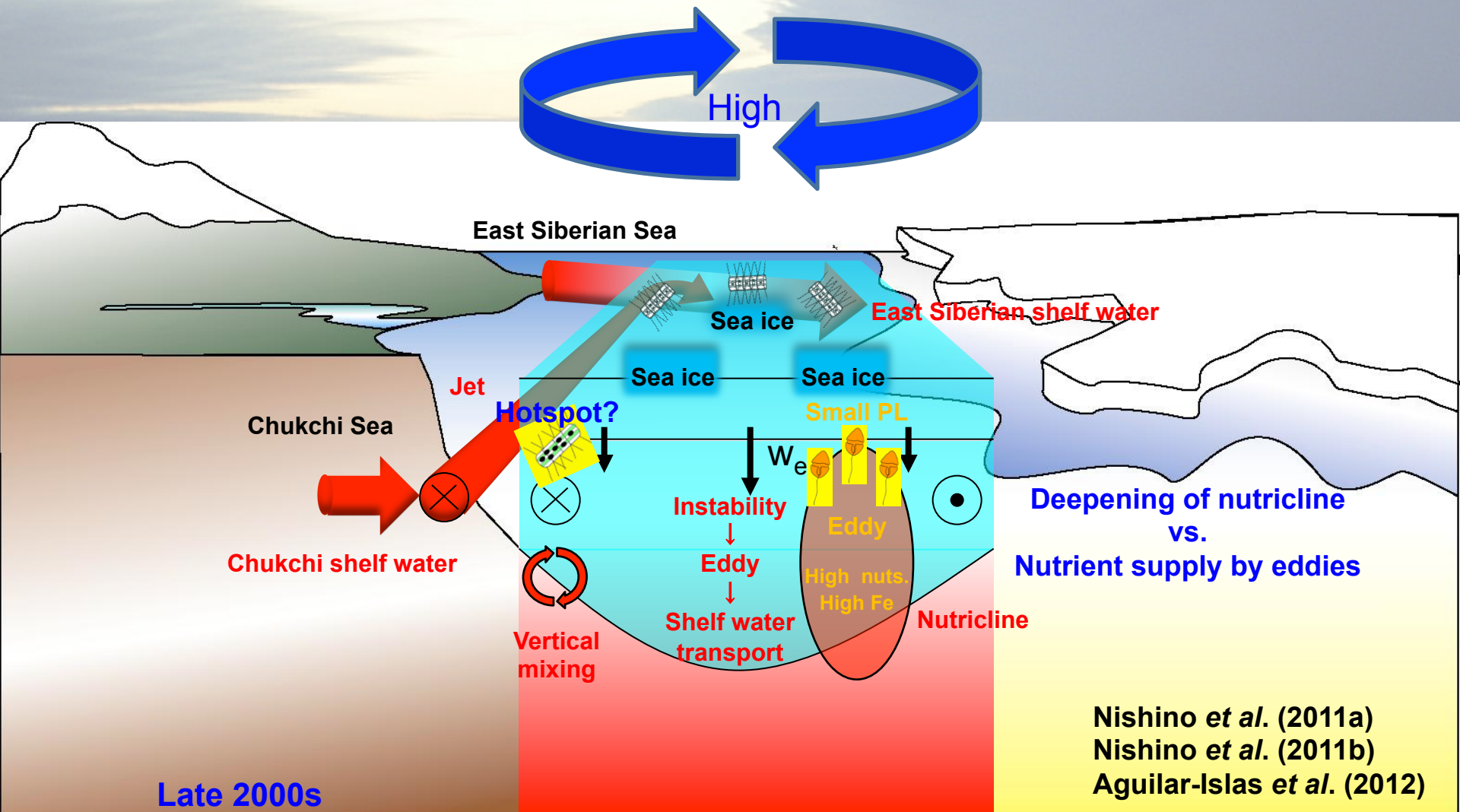
Pacific zooplankton and "Bering Sea fish" are now located in the Chukchi and western Beaufort Sea, respectively.

Seabird populations have declined with the drop in clam biomass and ice-associated cod. Gray whale feeding has shifted from the Northern Bering to the Chukchi Sea. Walrus are hauling out on land in unprecedented numbers.

Future Need Next Decade?

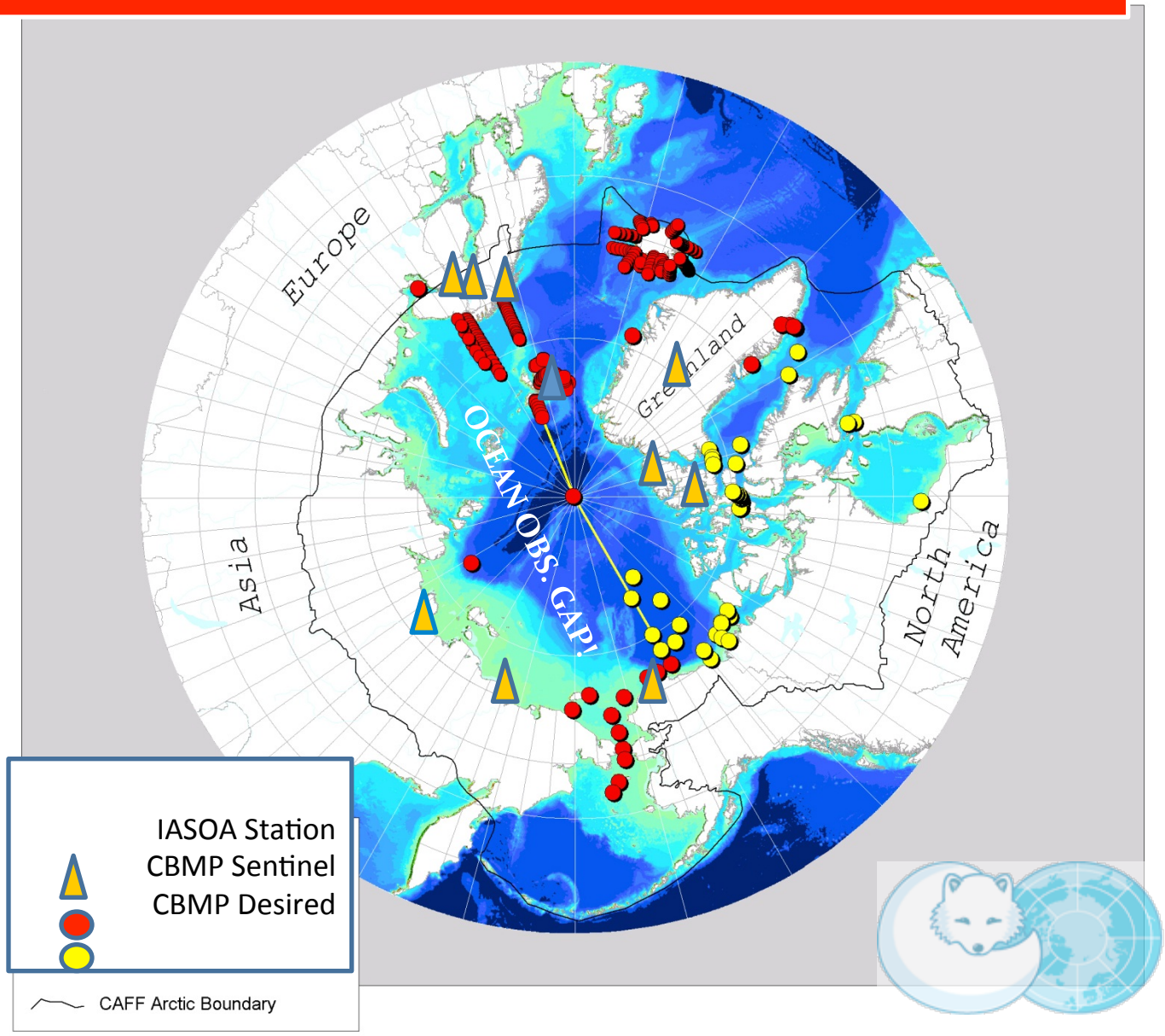
Enhancement of ocean circulation due to sea ice decrease

- ***– deepening of nutricline , inhibiting the shelf water spread***
- ***– producing eddies containing shelf water with high nutrients***



Nishino *et al*. (2011a)
Nishino *et al*. (2011b)
Aguilar-Islas *et al*. (2012)

NOAA WILL LEAD AND CONTRIBUTE TO ARCTIC COUNCIL OBSERVING ENDORSED NETWORKS



SAON
SUSTAINING ARCTIC OBSERVING NETWORKS

CIRCUMPOLAR BIODIVERSITY MONITORING PROGRAM

ARCTIC COUNCIL

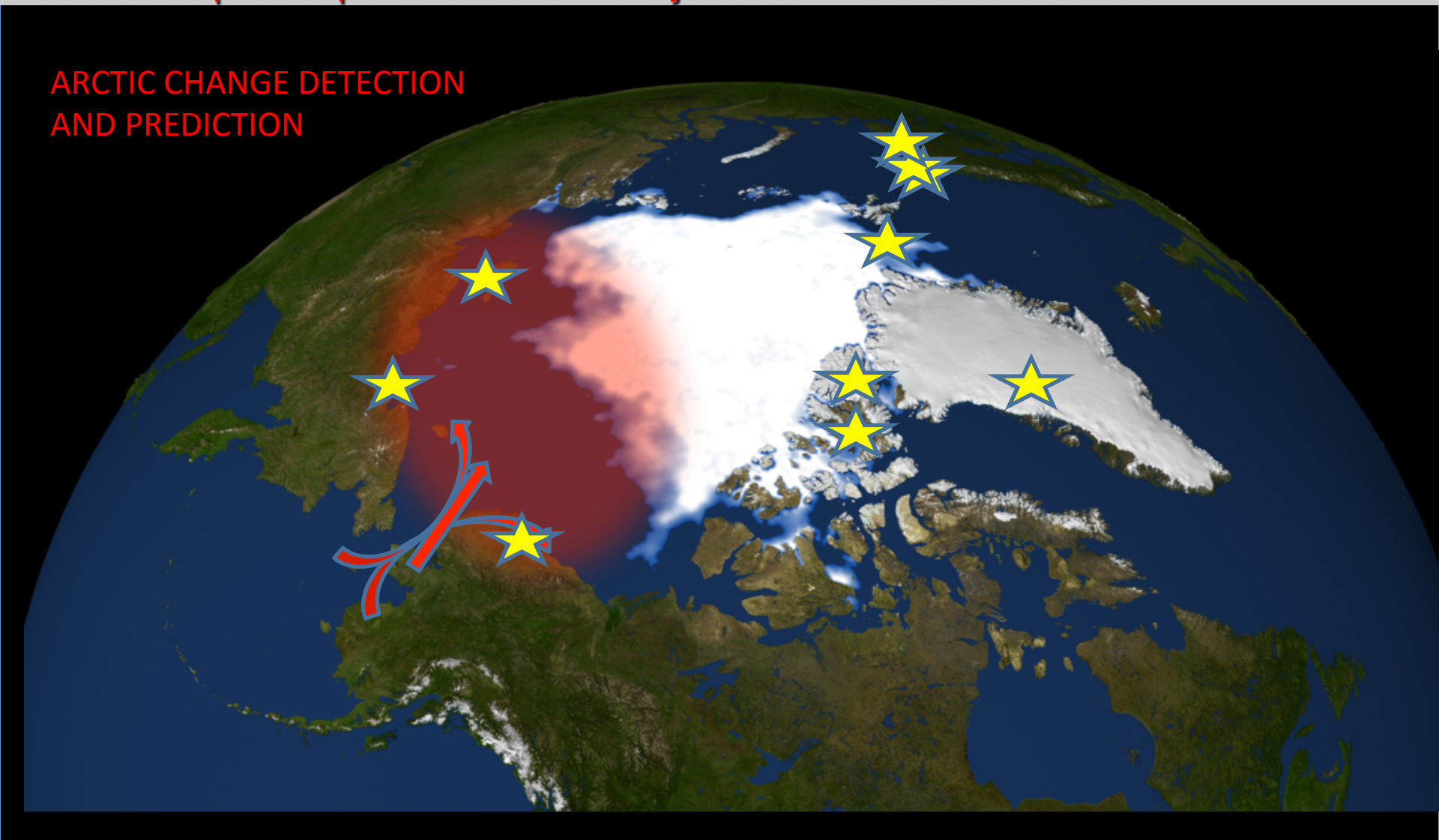
Unique Value-Successes: ARP-ESRL-Arctic Climate Observatories

- **6 of the Arctic Observatories recorded a CO_2 level of 400 ppm this year. Observations of pan-Arctic methane concentrations are ongoing.**
- **How does the Arctic atmosphere interact with the rest of the Arctic (marine, ice and terrestrial) system?**
- **What portion of the recent changes in the Arctic climate contribute to severe weather events in the middle latitudes?**

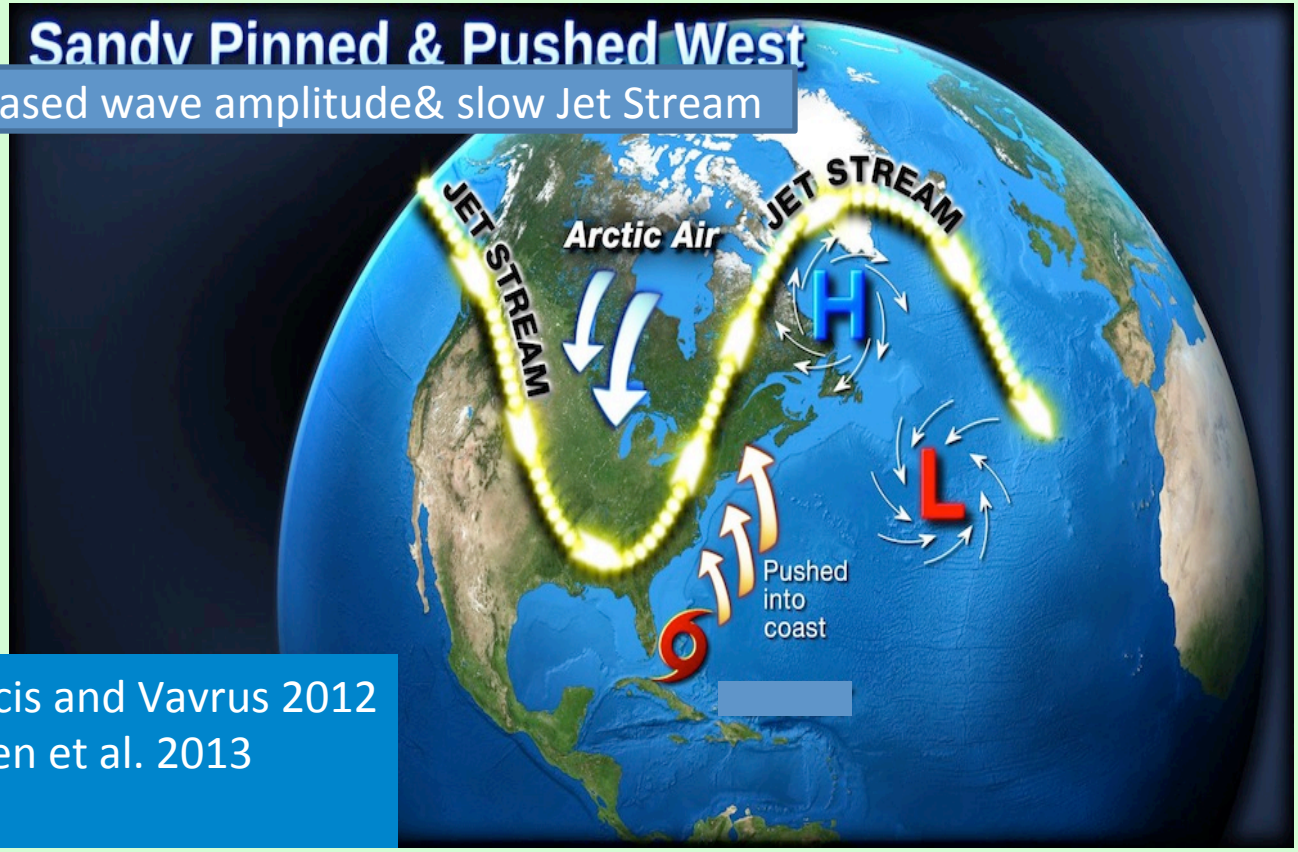
Co funding from Canada, Russia, Finland, Norway, Sweden, Denmark, NSF, GMD (Barrow and Summit)

T. Uttal Lead

Pacific-Arctic Sea Ice Loss from advection of heat from both the Pacific and Atlantic Gateways. Added Ocean Heat Storage and Heat Flux from New Sea Ice Free Areas affects also the mid-latitudes: RUSALCA results from the Pacific, NABOS results from the Atlantic and atmospheric trends from the **circum- Arctic observatories** will be used to **predict perturbations in the jet stream** further to the south.



Will Arctic changes lead to more mid-latitude weather extremes? Loss of snow and sea ice adds additional heat to atmosphere that leads to a greater chance for a breakdown of the Polar Vortex



Francis and Vavrus 2012
Screen et al. 2013

RUSALCA 2nd Decade

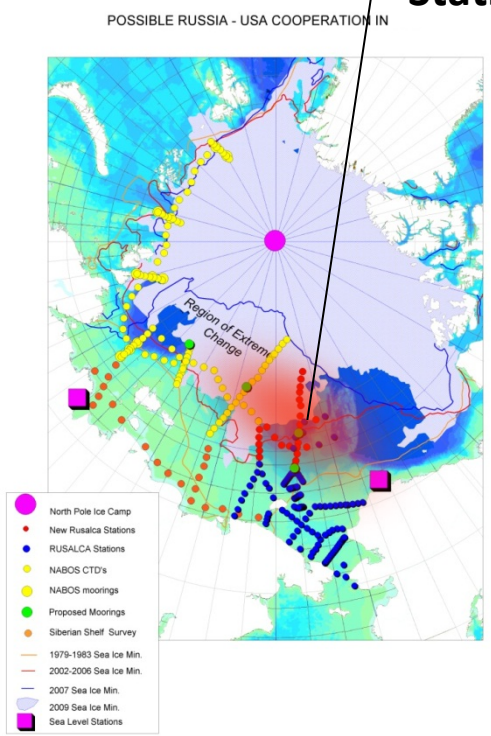
Warming Atlantic Water circulation in the Arctic, 200–800 m

Confluence of Atlantic Water with Pacific Water

Unsampled RUSALCA Stations

Northern RUSALCA Area

Actual RUSALCA Stations



Considerations for 2014-2019 sampling

2 U.S. Russian DBO lines

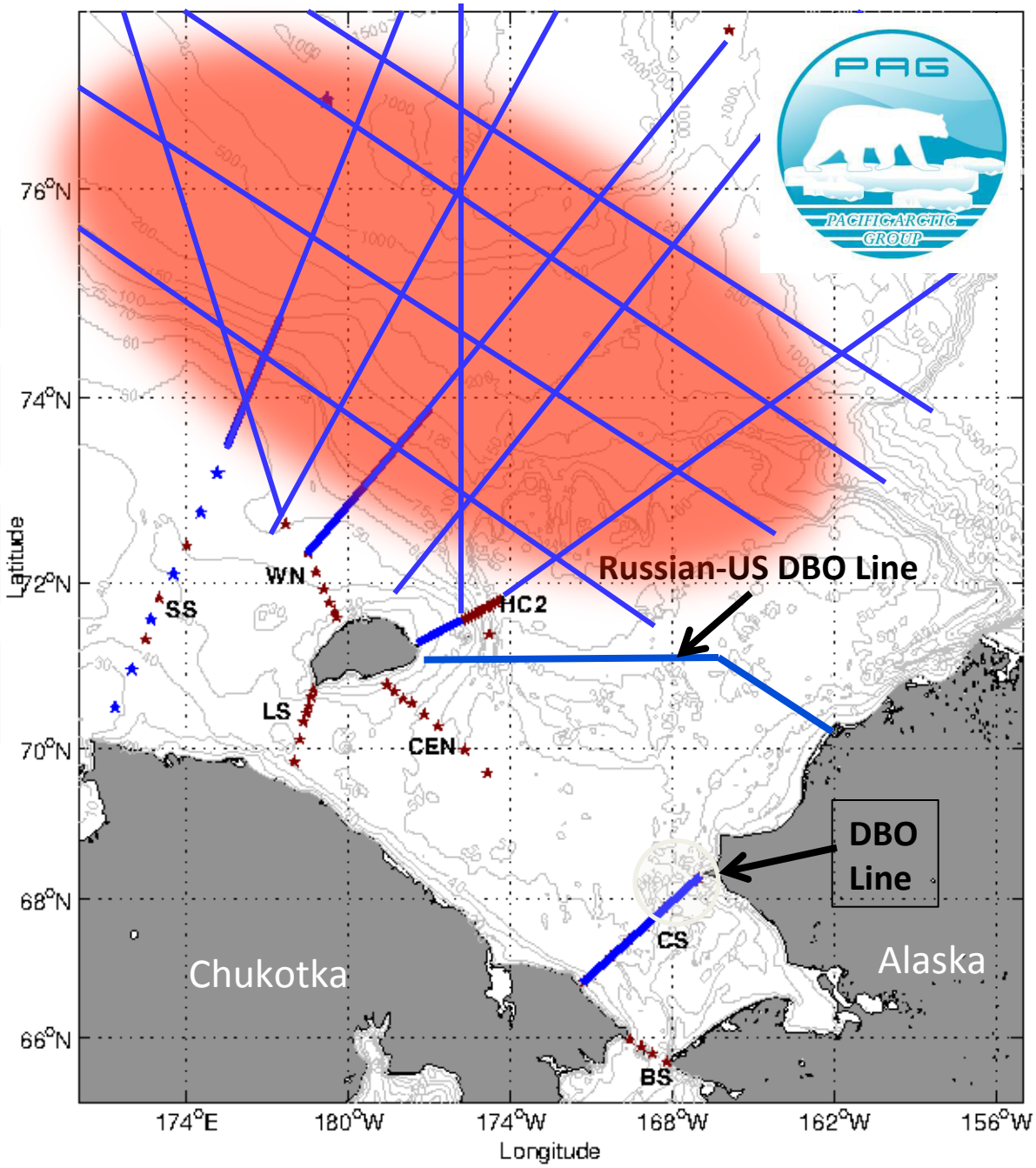
10 Repeat hydrography,

Ecosystem and Methane

RUSALCA + Korea, China, Japan, Canada

RUSALCA

2nd Decade !

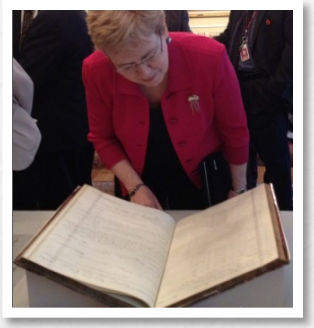


AWARD WINNING

RMetS

Progress toward a

RUSALCA CLIMATOLOGY



Old Weather Arctic

LARGE-SCALE ENVIRONMENTAL DATA RESCUE THROUGH CROWDSOURCING

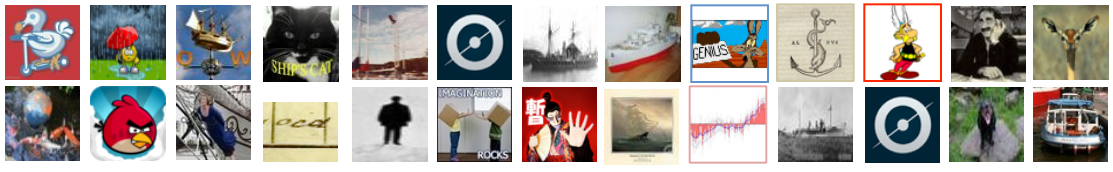
Kevin Wood

and

P. Brohan, J. Overland, E. Hope, G. Smith, N. Soreide, M. Mollan, L. Mishonova, A. Smith,

and

20,000 Citizen-Scientists:



CHALLENGES

- Need to define a new long-term (5-10 year) program path that blends knowledge from:
  - prior Program activities,
  - the overall state of knowledge,
  - Current NOAA and national priorities
  - Knowledge of the internal resource level
  - Consideration of the potential partnership opportunities.

- Simultaneous evaluation of all these factors will be needed to select the most efficient set of Program goals and objectives.

- Once a path is chosen, the major challenges will be solving the many execution/operation/logistic issues that will arise while remaining alert to the need for course corrections in the face of new information

Thank

You